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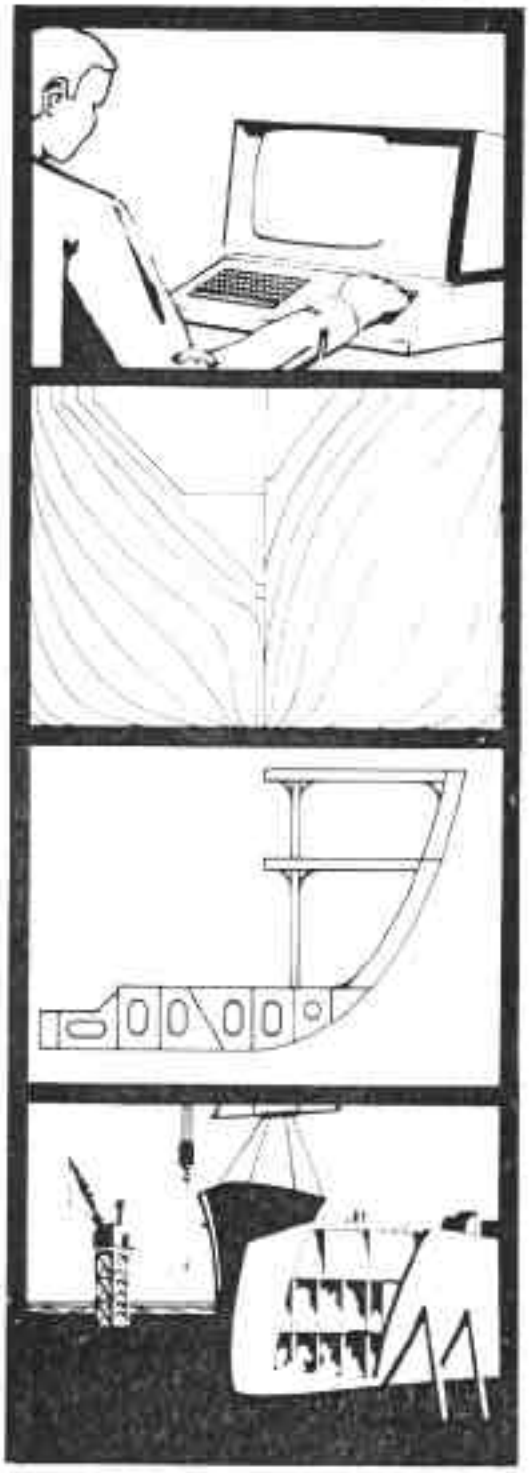

R ESEARCH
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IN
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AUTOPART, AUTONEST, AUTODRAW - SYSTEMS FOR INTERACTIVE GENERATION OF PRODUCTION INFORMATION

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SYNOPSIS

This paper describes AUTOPART, AUTONEST and AUTODRAW, a suite of new AUTOKON programs for parts definition, nesting, verification and general drafting. They are implemented in interactive graphics technology using a mini computer and a Tektronix 4014 storage tube for communication.

AUTOPART and AUTONEST may be used as a stand alone system providing N/C cutting information, partly replacing similar functions of the AUTOKON batch system. However, for shipbuilding the 3 modules should be seen as an integral part of the whole AUTOKON system, offering higher efficiency and increased flexibility in the production and of the process.

INTRODUCTION

The development of an "interactive AUTOKON" has been dealt with in a variety of presentations and papers at previous REAPS conferences. We have explained the reasoning behind our development, the philsophy and consepts and we have even presented details on actual operating results. For those interested, reference is made to REAPS proceedings from earlier years. So much has been written and spoken about interactive computer graphics application in general, that I assume the reader is familiar to the pro's and con's.

Our first exposure to a practical application in this technology was AUTONEST, started in 1974. It was a typical pilot project, which main purpose was to learn what this technology was all about. We learned that there was a long step from creating a picture that could be move around on the screen - to a down-to-the-earth useful and efficient production tool.

The concept for an entirely new technical information system, called "interactive AUTOKON" was developed in 1976/77, and has been continuosly subjected to further detailing, in terms of data base design and system design. Obviously we were faced with a pretty long term effort. But at the same time short term results in form of practical applications were demanded. This was not an easy balance.

We had an existing AUTOKON system, so we decided that the short term results should be made in such way that they could enhance the existing AUTOKON system, at the same time as being parts of the future interactive AUTOKON. Since lofting and work drawings still catered for 50-60% of the hours in design and work preparation of steel, and since we had already developed AUTONEST, we decided to concentrate the short term developments to make interactive production preparation tools.

AUTOPART, AUTONEST and AUTODRAW cover partcoding, nesting, verification and general drafting and are such tools. To place them in their right position in the AUTOKON "land scape", AUTOKON-79 is used as departure point. Exhibit 1 shows AUTONEST as an alternative function to NEST.

In Exhibit 2, AUTOPART and AUTODRAW have been added. As will appear later, AUTOPART has many of ALKON's basic functions, but does by no means replace ALKON in the overall AUTOKON context as an integrated design and production system. AUTODRAW has no parallell in the batch system, and should basically be considered major enhancement to the existing drawing facilities of AUTOKON-79.

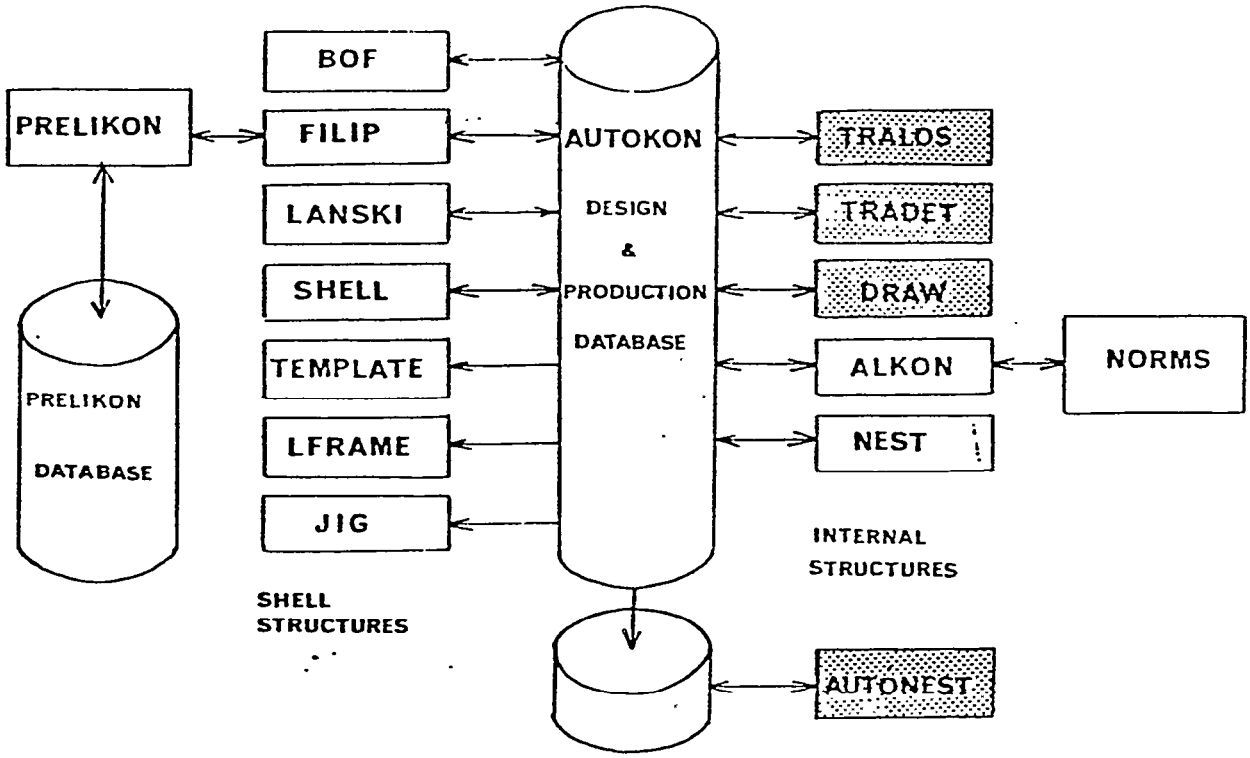


Exhibit 1

Layout of the AUTOKON-79 system, including the interactive nesting module AUTONEST.

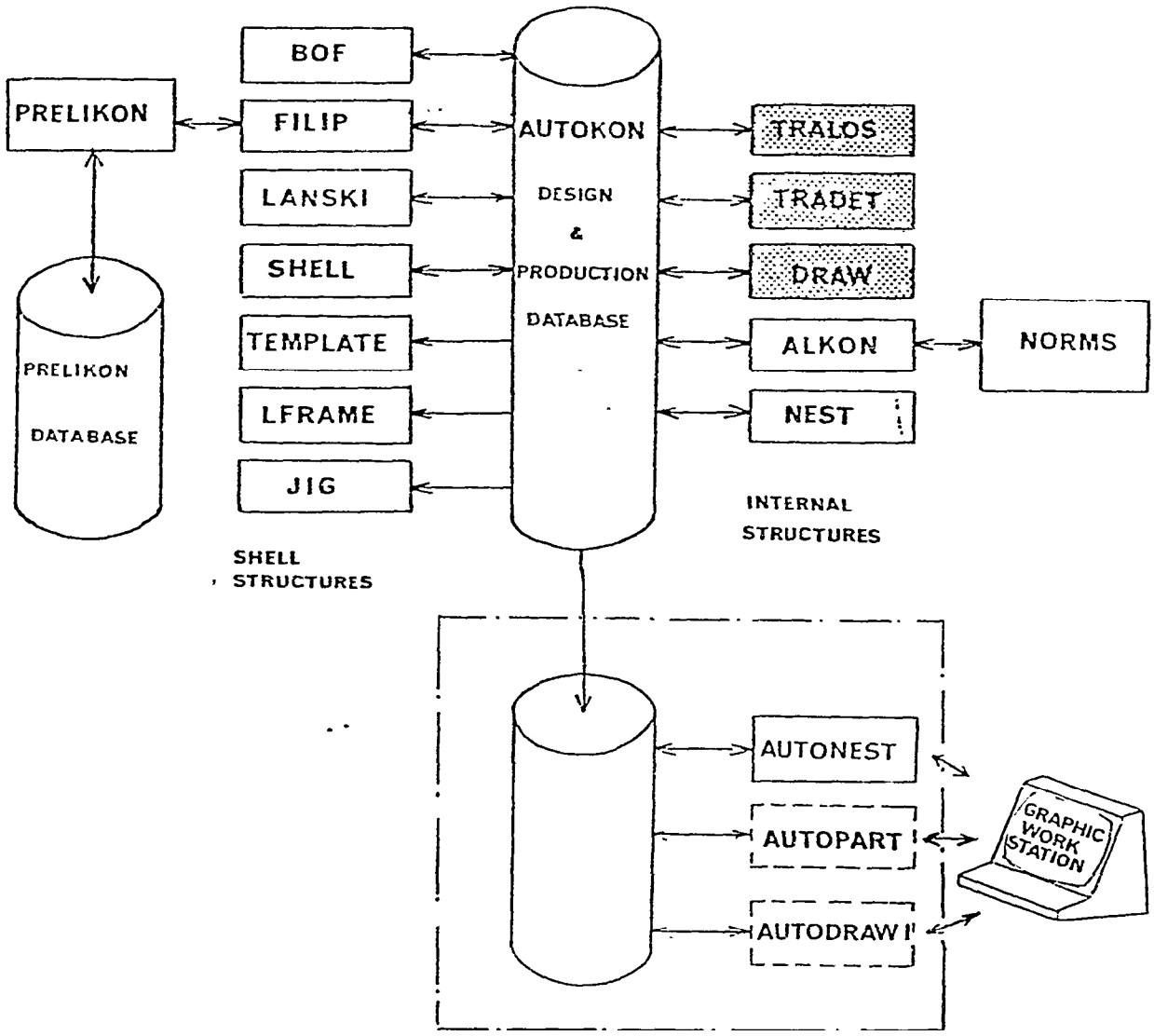


Exhibit 2

AUTOKON-79 and the modules AUTOPART and AUTODRAW.
The three modules AUTOPART, AUTONEST and AUTODRAW are a system for Interactive Generation of Production Information.

AUTONEST

AUTONEST has been in successfull operation for more than 2 years in several yards. It is working on a Norwegian NORD-10 16 bits mini computer as well as on a PRIME P550. A Tektronix 4014/l storage tube with EGM option is used. An attempt to convert AUTONEST to a Tektronix 4081 refresh work station (without using a host computer) has not been quite successful yet.

The modern high speed transmision long distance network as in Canada has made it interesting to run AUTONEST from remote on a large central computer. We have in our plans to implement it on an UNIVAC 1110 to try out these possibilities.

Experience shows that the average time for a medium complex format is 0,5-1 hour to complete the job.

AUTONEST is an entirely self contained system in the sense that both lay-out (nesting), sequencing and papertape generation is done by AUTONEST itself. See Exhibit 3.

The parts to be nested in the AUTOKON-79 system are generated by ALKON. Alternatively, they will be made interactively by AUTOPART.

The jig-saw puzzle is fully controlled by the user. He may move rotate and mirror image a part in any manner he wants. In case of overlapping the system is providing self control, and any point of the screen may be blown up in full scale for detailed checking if necessary.

The user may nest a cluster of parts and treat it as one part. This is very usefull in putting pre-nested -details around in a format to utilize scrap, especially interesting in connection with plasma cutting. The high cutting speed allows it without making the cutting machine a bottleneck as often is the case in conventional oxy-cutting.

The sequencing is done interactively in a very straight forward way. A little light point is following the predefined marking and part coding sequence. This point is stopped by the user at places where bridges are desired. He is completely free to chose sequence, and auxilliary functions may be freely manipulated at this stage.

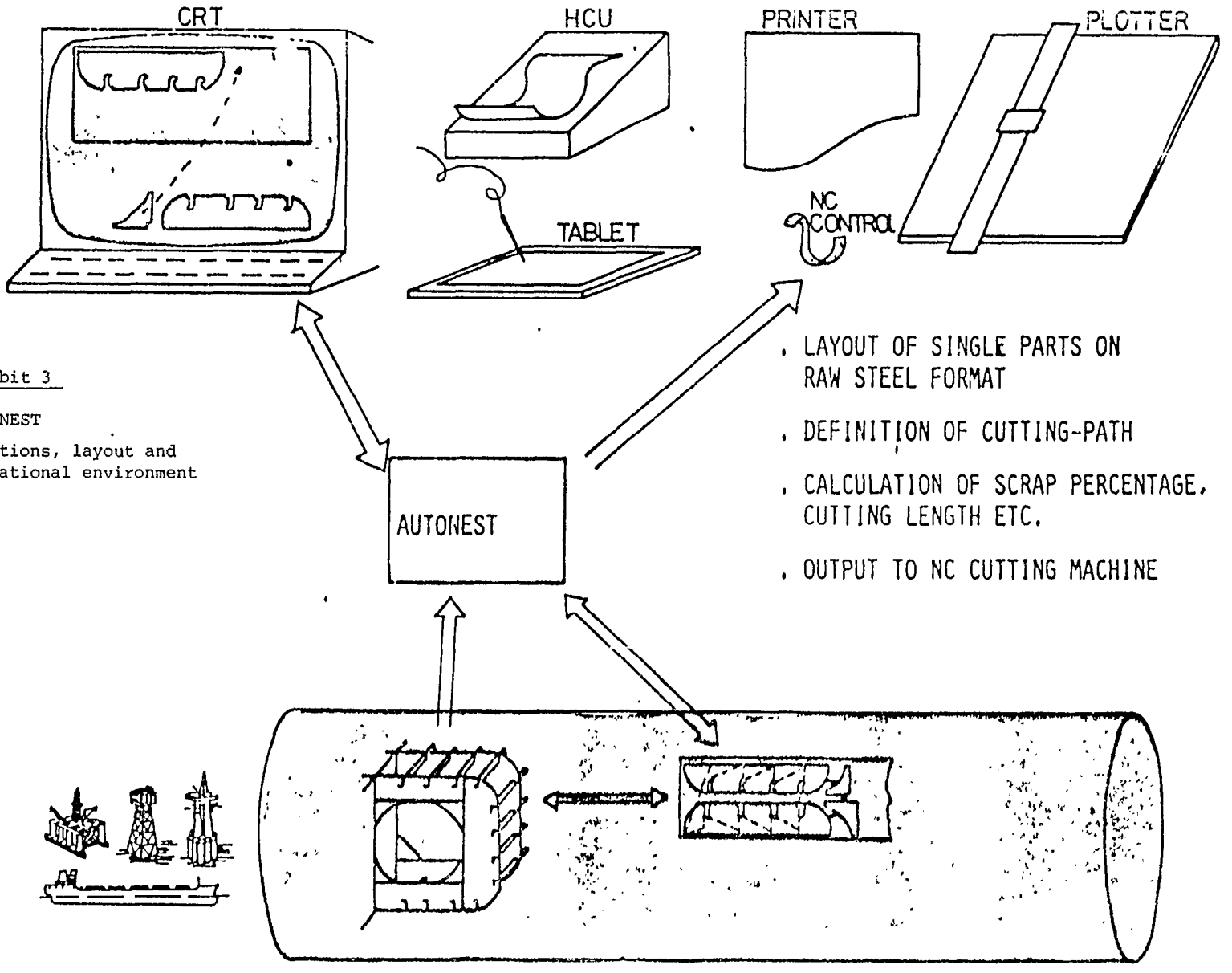


Exhibit 3

AUTONEST

Functions, layout and operational environment

AUTOPART

By means of AUTOPART, the user may

define parts "from scratch" as a sequence of basic geometric elements like: straight line, circle, etc, without any reference to predefined information.

define parts, referring to previously defined contours, generated by AUTOPART itself or by AUTOKON-79.

define macros such as cut outs, holes etc. and use them any where in the part definition.

modify parts previously defined by AUTOPART

split parts in smaller parts. (under develop).

define "drawing" symbols for manipulation by AUTODRAW.

See Exhibit 4 for layout and functions.

The "Language" is fairly similar to ALKON. In ALKON, the user writes a manuscript which comprises all statements necessary for generating the whole part in one run. If he has made a mistake, he will not know until he gets the verfication of the "paper-tape". In most batch-processing environments this takes anything from 0.5 hour to 2 hours. Sometime even more.

When the user is coding the same part in AUTOPART he will generate one contour element after the other and immediately see the result of his commands. When an error occurs he can correct it immediately before proceeding. He can follow his coding almost as in the "old days" when he was drawing parts by hand. The total elapsed time of the job is reduced to the effective time the user needs to code the part. We believe he will also work more efficiently than in a batch system.

Exhibit 5 shows the part in the final stage of coding. In Exhibit 6,7,8 and 9 the user has asked for control of various data incorporated in the final part description.

The old ALKON user will probably ask: Do we need both ALKON and AUTOPART?

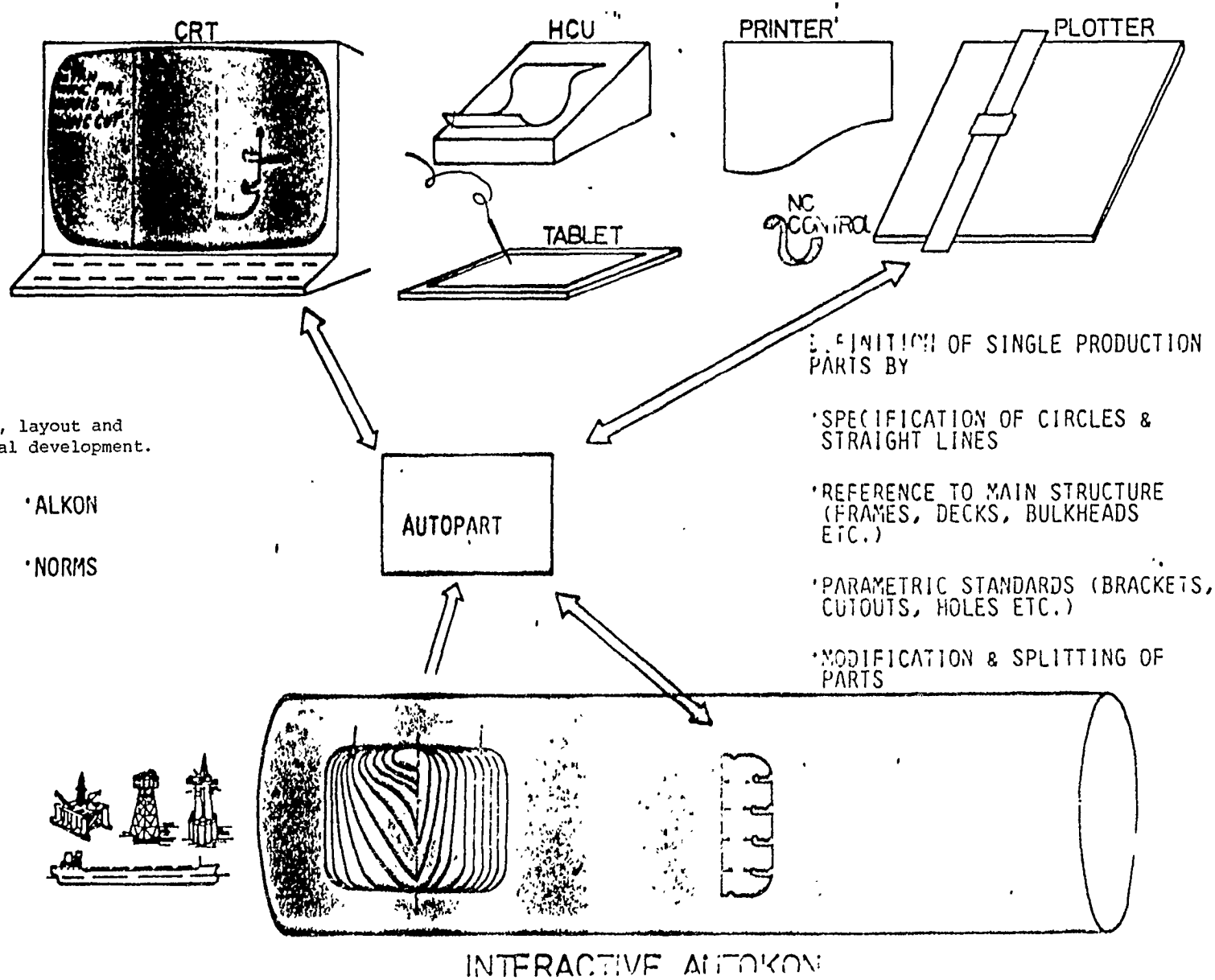


Exhibit 4

AUTOPART.

Functions, layout and operational development.

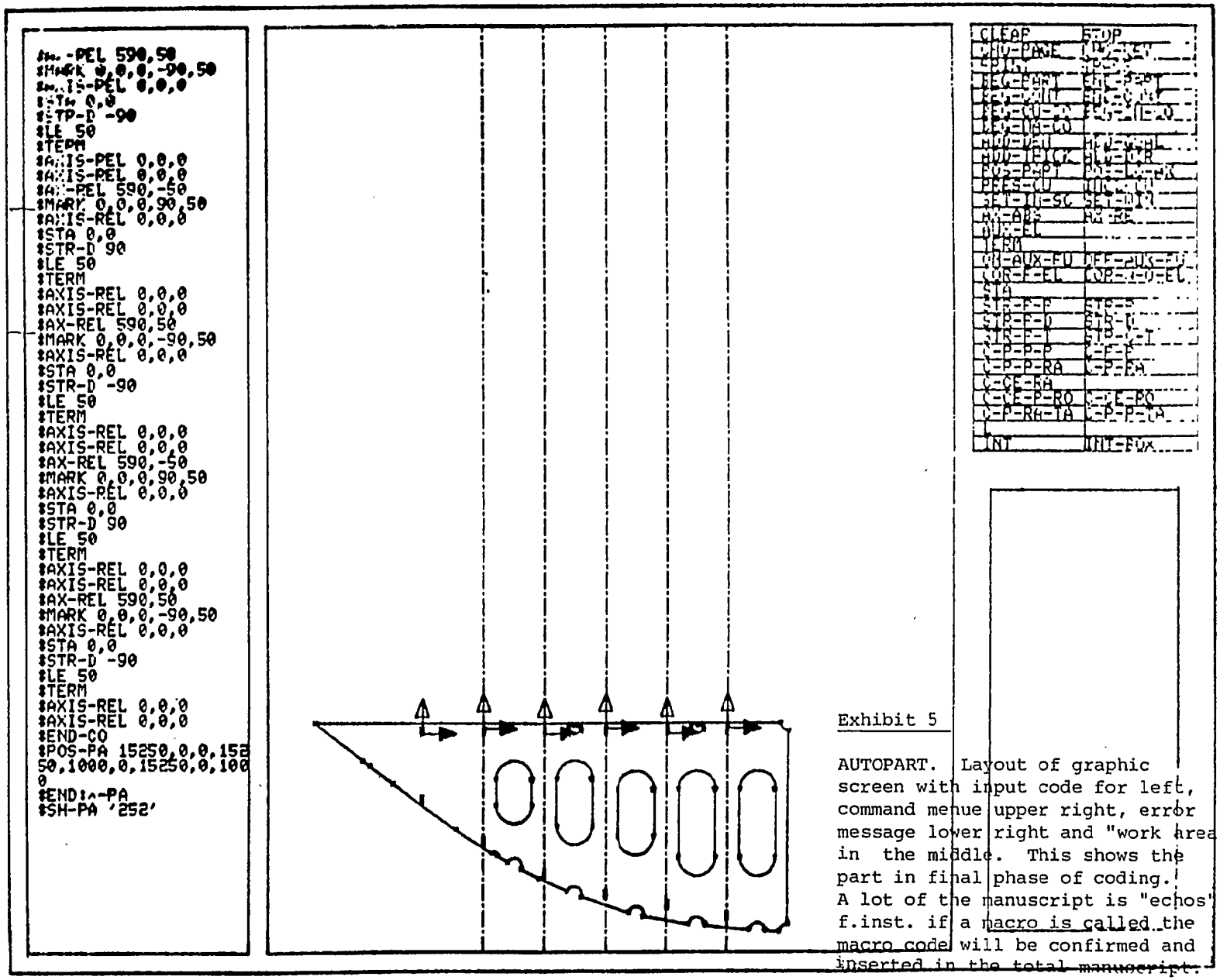


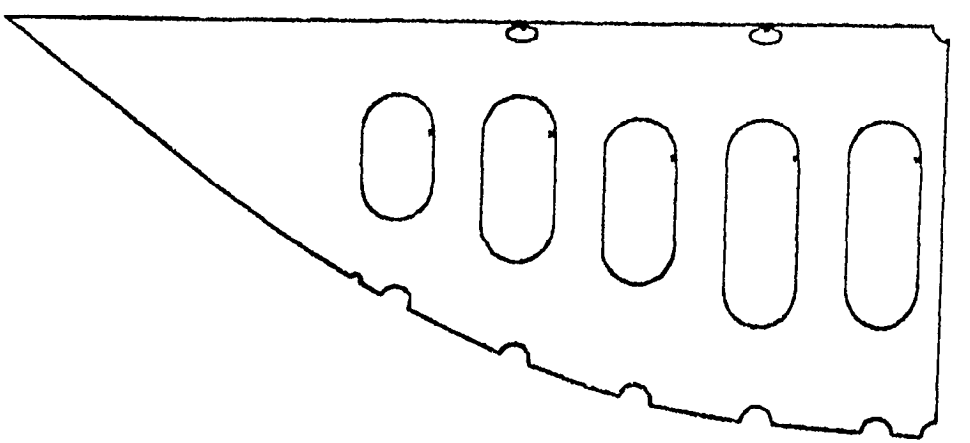
Exhibit 5

AUTOPART. Layout of graphic screen with input code for left, command menue upper right, error message lower right and "work area" in the middle. This shows the part in final phase of coding. A lot of the manuscript is "echos", f.inst. if a macro is called the macro code will be confirmed and inserted in the total manuscript.

```
1
STATUS          :
1
GEOM. REC.      :
543
AU.. FUNC.REC. :
550      0
TE..T REC.      :
0
REF. POINT      :
-1610.00    1419.00
CONT. NO.       :
5       1       0
0
CONT. TYPE      :
102
ICTYPE          :
1
STATUS          :
1
GEOM. REC.      :
543
AUX. FUNC.REC. :
544      0
TEXT REC.       :
0
REF. POINT      :
-1475.00    1969.00
$CLEAR
```

Exhibit 6

AUTOPART. Control view of external countour and holes of the finished part. Most of the text is control output.



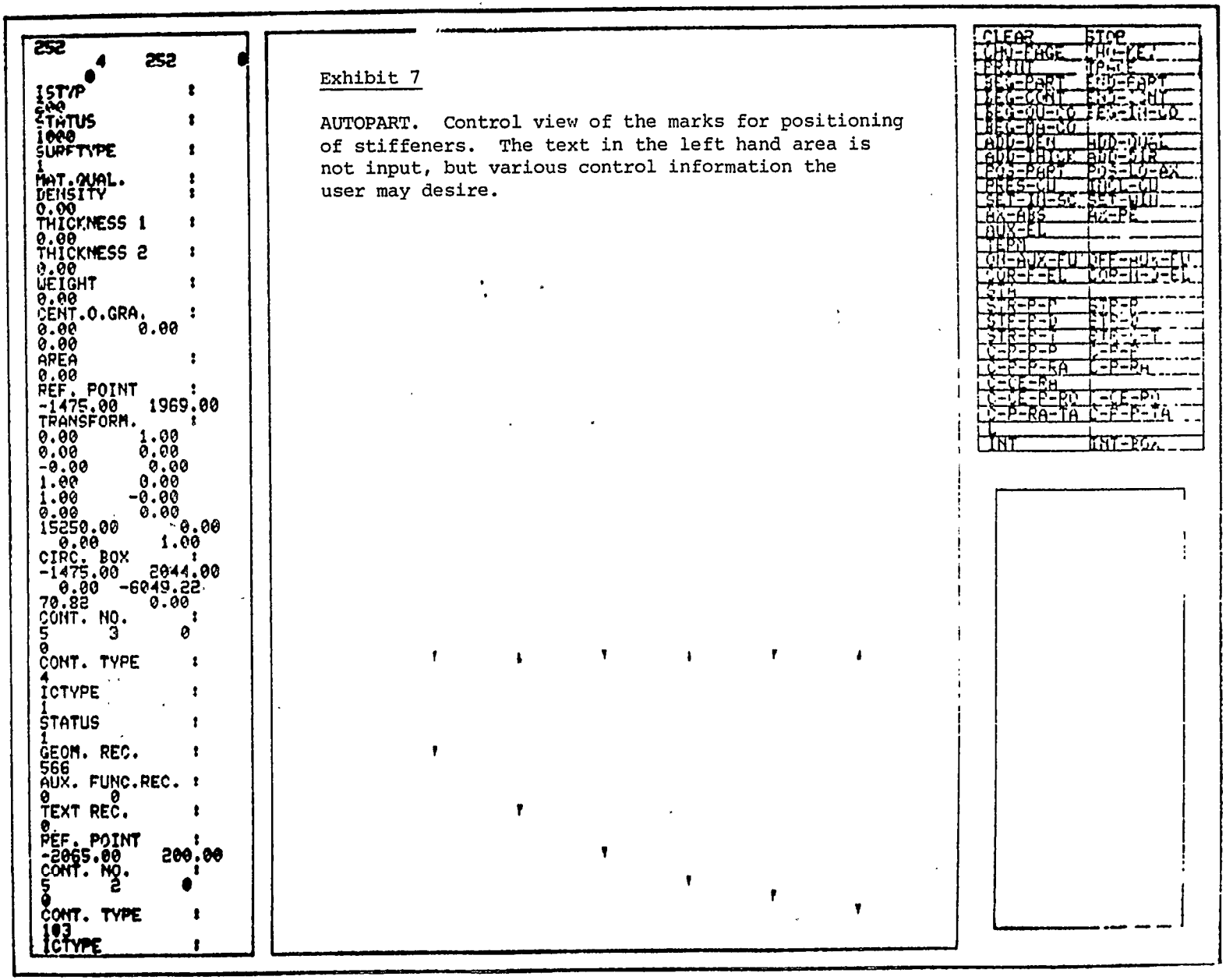


Exhibit 7

AUTOPART. Control view of the marks for positioning of stiffeners. The text in the left hand area is not input, but various control information the user may desire.

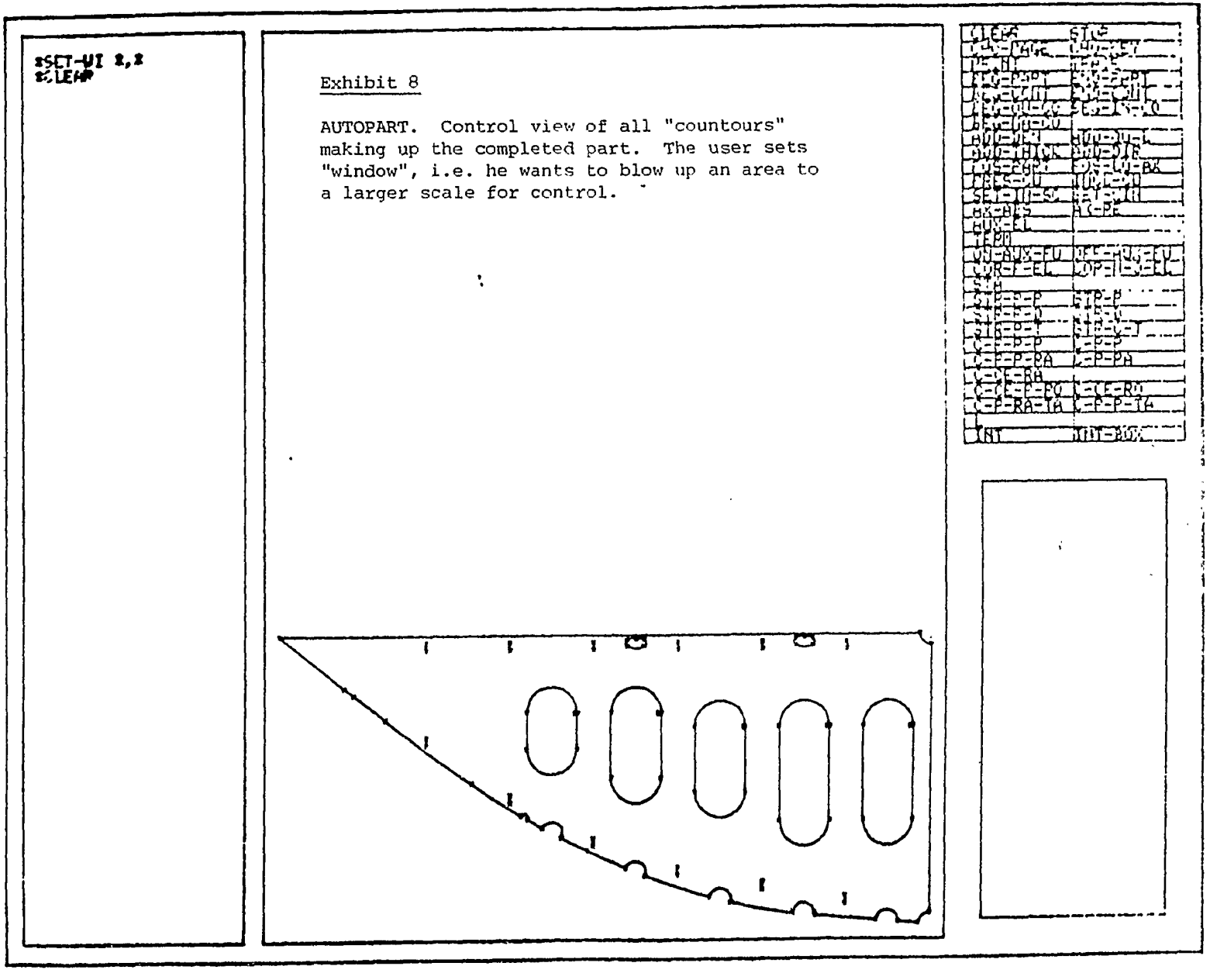


Exhibit 8
AUTOPART. Control view of all "countours" making up the completed part. The user sets "window", i.e. he wants to blow up an area to a larger scale for control.

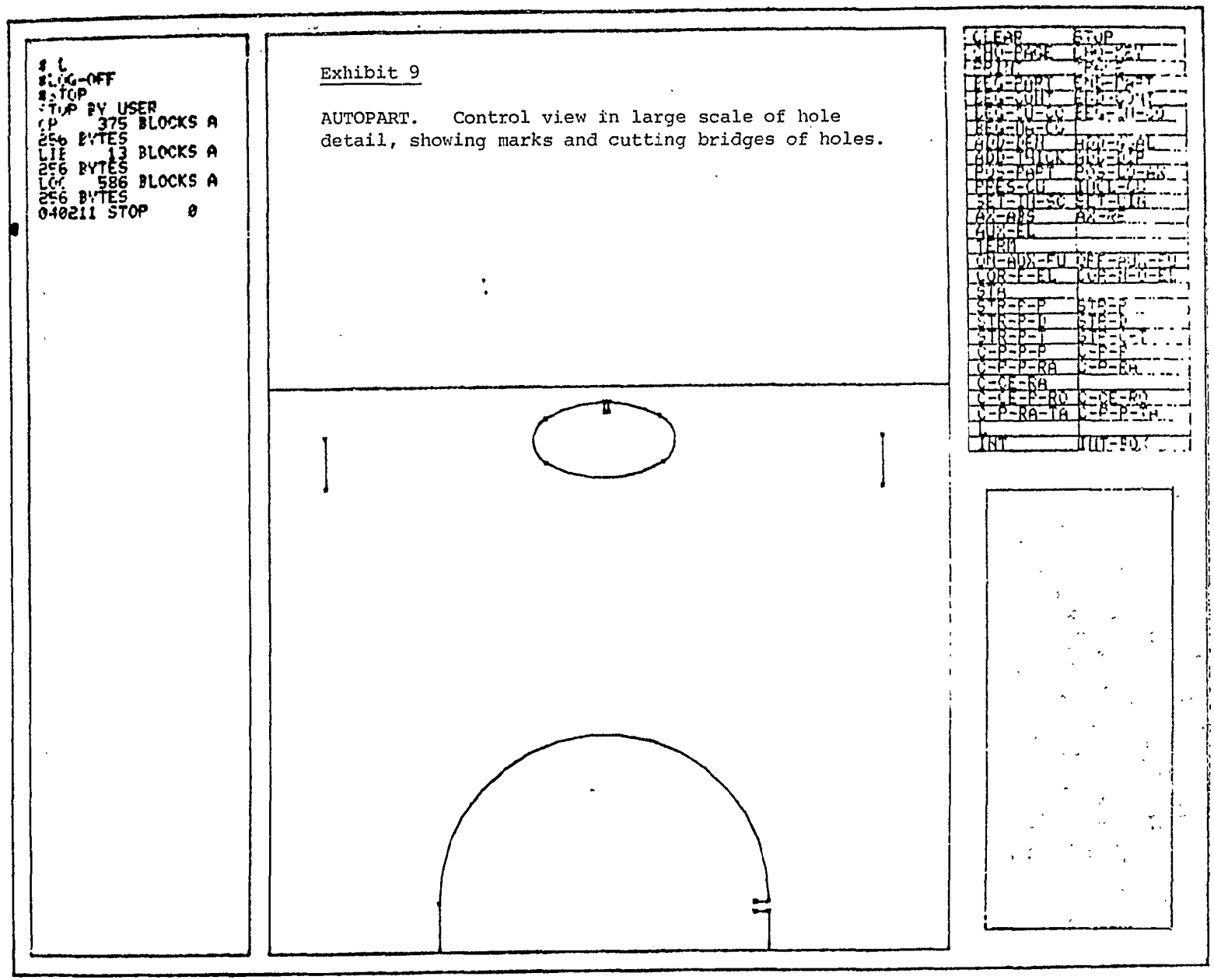


Exhibit 9

AUTOPART. Control view in large scale of hole detail, showing marks and cutting bridges of holes.

will be

The answer depends on what we are going to do. AUTOPART will be sufficent to do lofting on a part by part level either from a "scratch" basis or when utilizing all kind of reference contours from AUTOKON-79. But the reference contours themselves are very efficiently generated by the 10 new statements of ALKON. These new statements in their turn get their reference information from the structural model of AUTOKON-79. That means from BOF, LANSKI and TRADET for the shell structure and from TRALOS and TRADET for the internal structure. The BOF/LANSKI data have always been available before partcoding. But imagine the amount of information now available on internal structures, thanks to TRALOS and TRADET. ALKON is also used to make face contours of webframes, stringers, and other "free" contours to complete the TRALOS/TRADET structure for detailing of documentation by the (batch) DRAW module.

The user may define his screen layout, he may easily change from one mode (pointing on screen menue) to another (key boarding the commands). Menues, manuscripts, an error messages are in separate areas and do not mess up the geometry "work area".

AUTODRAW

AUTODRAW is an interactive graphics system and should be distinguished from the AUTOKON-79 module DRAW. See Exhibit 10 for layout and main functions.

Even if AUTOKON-79 can generate quite a variety of layout and block drawings, they are only predefined views and contain allmost nothing but geometrical information. By a thumb rule, we may classify them as only 2/3 complete. Therefore, quite a lot of efforts are needed to "shine up" and complete them. By dimensions, scantlings, material codes, reference to and drawing of details, job instructions, and whatever other "text" considered necessary to make the drawing serve as an information carrier for parties concerned. All these information is not very easily dealt with by batch programs. But the interactive graphics technology is excellent for this purpose.

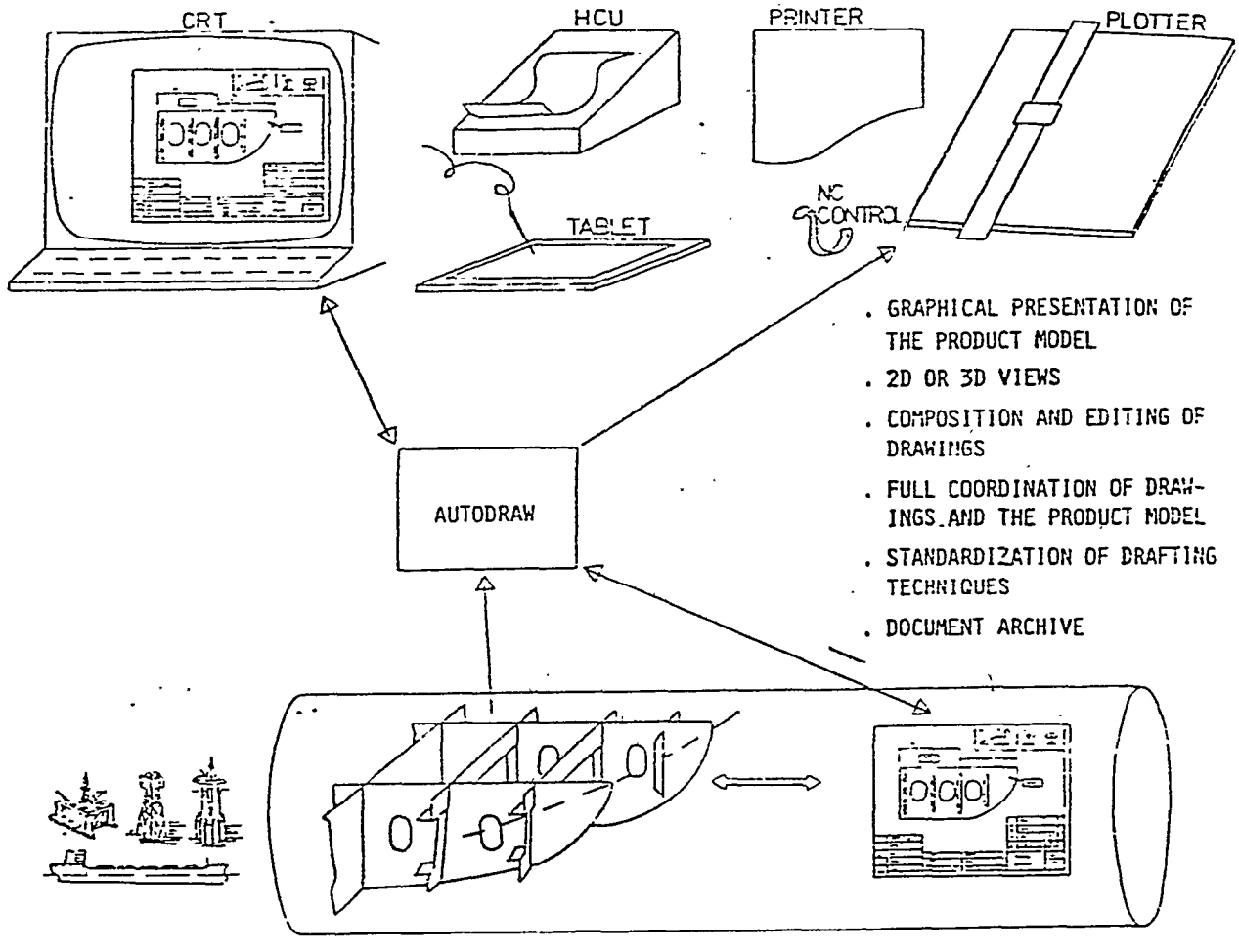
The main purpose of AUTODRAW is to manipulate predefined geometry, from AUTOKON-79, from AUTOPART or in the future, from the new AUTOKON "interactive steel design" system. More specifically the function of AUTODRAW will include:

1. Verfication

   of contours, tables, text

Exhibit 10_

AUTODRAW, its functions and operational environment.



2. Generation of drawings

a) Compostion or lay-out

b) Completion by:
- text
- symbols
- dimension lines
- indentification, reference
- "drawing techniques" - "cosmetic" treatment

c| Generate other views:
- orthogonal
- perspective
- axinometric/iSometric

3. Build and administrate document library

- Storing, retrieval, distribution

Most of functions under 1) and 2) are operating in a pilot stage. But generally AUTODRAW is 'still under development.

In addition to above functions, AUTODRAW may be used in the same way as a graphics turn key system, as a "drafting" tool to make "pictures" on the screen. As far as structures are concerned, this function is a minor one. We do not need it so much, since the whole idea with AUTOKON is establish a computer based "product model" and manipulate it. A drawing is basically an extract of the "structural model" information presented on a piece of paper in some desired view and scale and completed with additional information to make this document complete.

Example

The various parts of a double bottom structure have been made by AUTOPART and stored in their proper position and orientation within the structure.

By means of AUTODRAW the user may ask for the whole structure and compose a drawing with orthogonal views. (Exhibit 11). when making the composit, he may either move around single data, or he may define a certain collection of information as a "segment" which he may move as a whole by using the cursor. (Exhibit 12). If he wants a perspective, he will get it. (Exhibit 13). This shows the potential of having a very flexible documentation technique using one single source of information, the "product model".

The problem of removing hidden lines is under solution in a methods development, see Exhibit 14. A more shipbuilding type example of this problem appears from Exhibit 15, where a part is seen through a hole of another part.

Since all contours reflect predefined objects, any dimension from any point to another may be derived by pointing with the cursor on the respective points. The dimension will be displayed and the user may locate it with proper "dimension lines" by using the cursor. (Exhibit 16).

Text may be generated in any size, shear, and line angle. The user simply operates the Tektronix key board as a "typewriter" together with the cursor. Exhibit 17 has been "written" by AUTODRAW. All text is included when later asking the plotter to generate the drawing on paper.

Exhibit 11

AUTODRAW

Orthogonal views of a double bottom structures.
The drawing is made on basis of parts generated
and stored by AUTOPART.

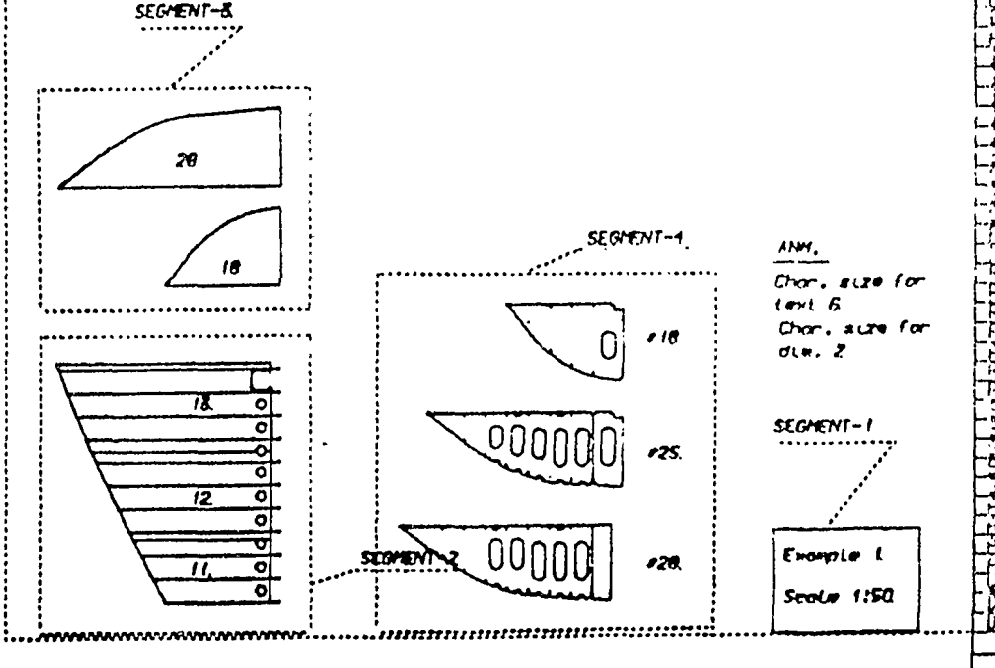
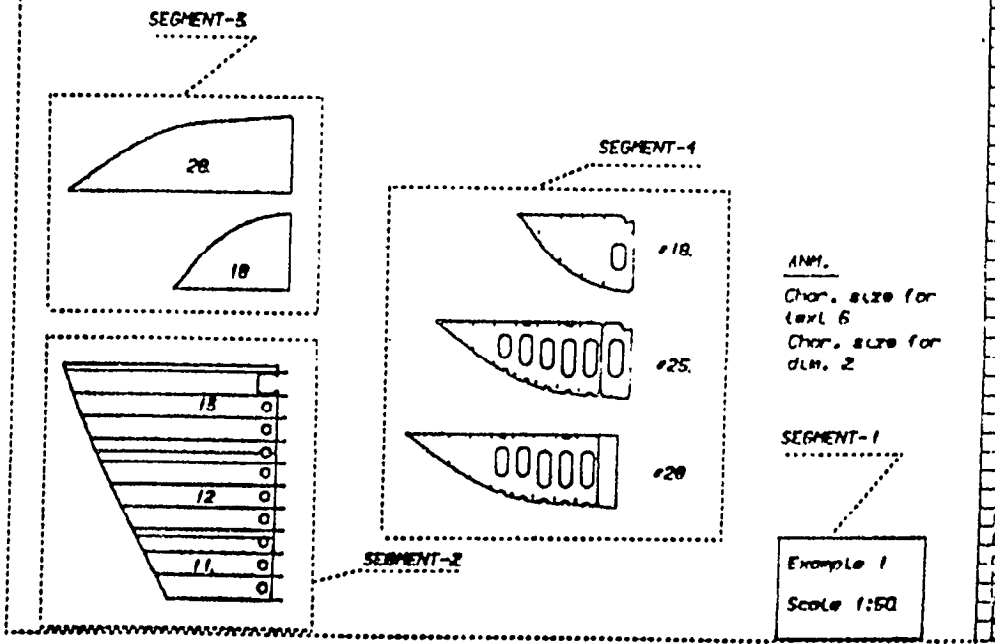


Exhibit 12

AUTODRAW

The user has asked the system to change the lay-out of this drawing by moving a group of information (segment 4) as compared to exhibit 11.

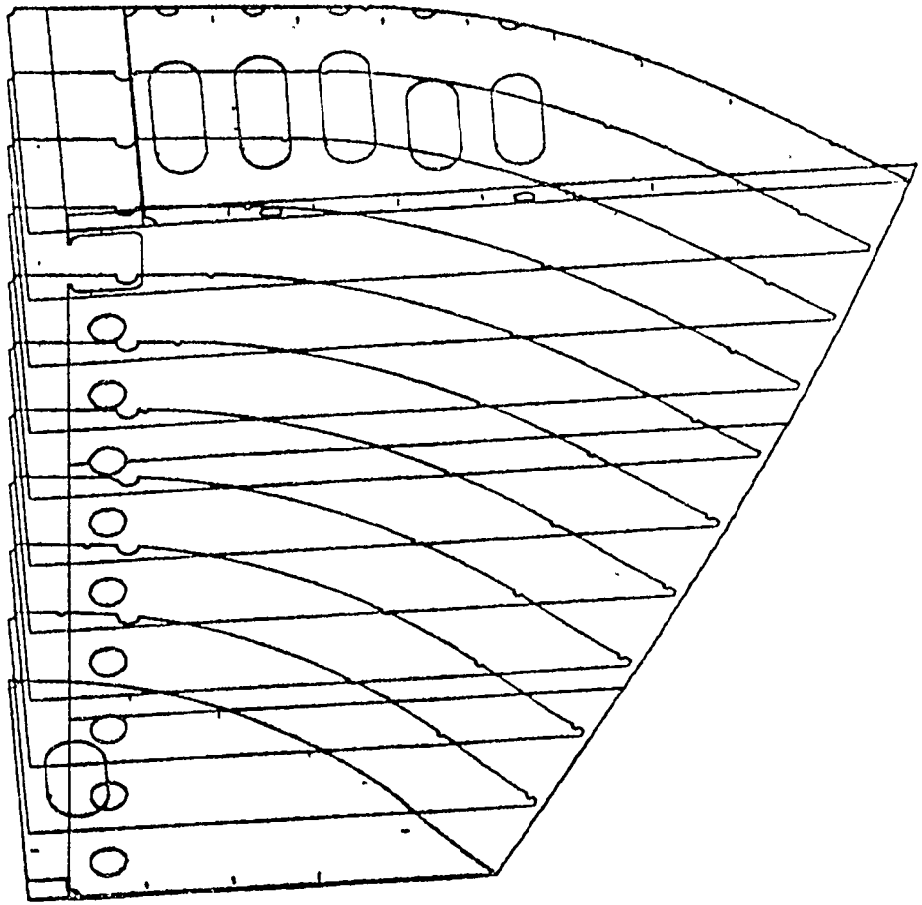


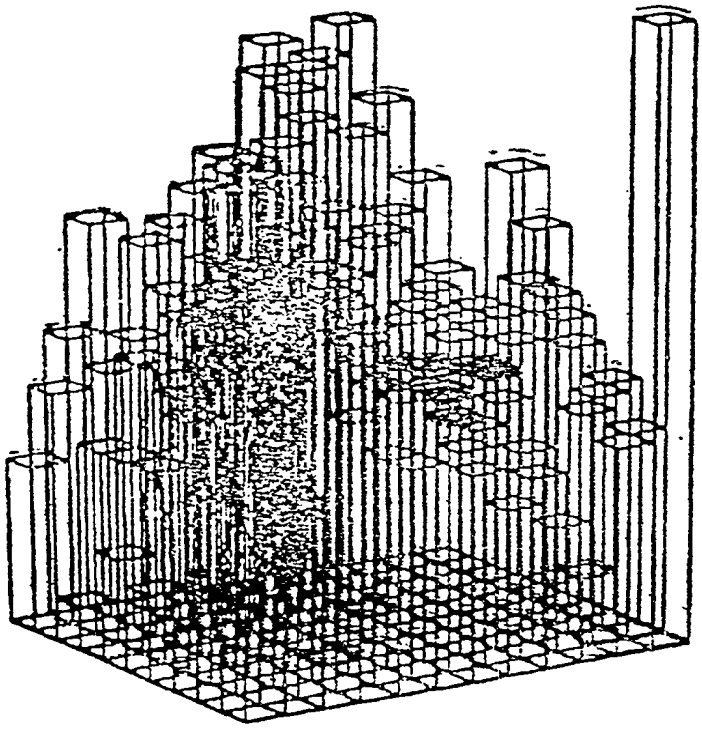
```
$END-SEG
$[illegible]-SEG SEGMENT-2
$[illegible]-PA  '18'
$[illegible]-BJ
$[illegible]E-PA '131'
$[illegible]-PA  '28'
$SH-[illegible]BJ
$[illegible]E-PA '231'
$[illegible]HE-PA '282'
$END-SEG
```

Exhibit 13

AUTODRAW

The same information as before, presented in a perspective view.





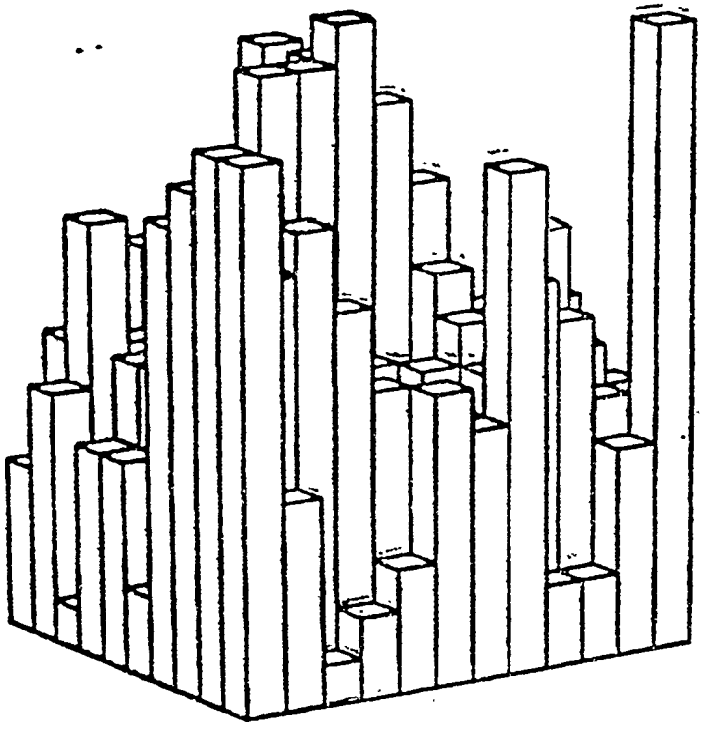


Exhibit 14

Example showing removal of hidden lines. Results from a methods development project, supporting the AUTODRAW development.

Exhibit 15

Removal of hidden lines. Results from a methods development project, supporting the AUTODRAW development.

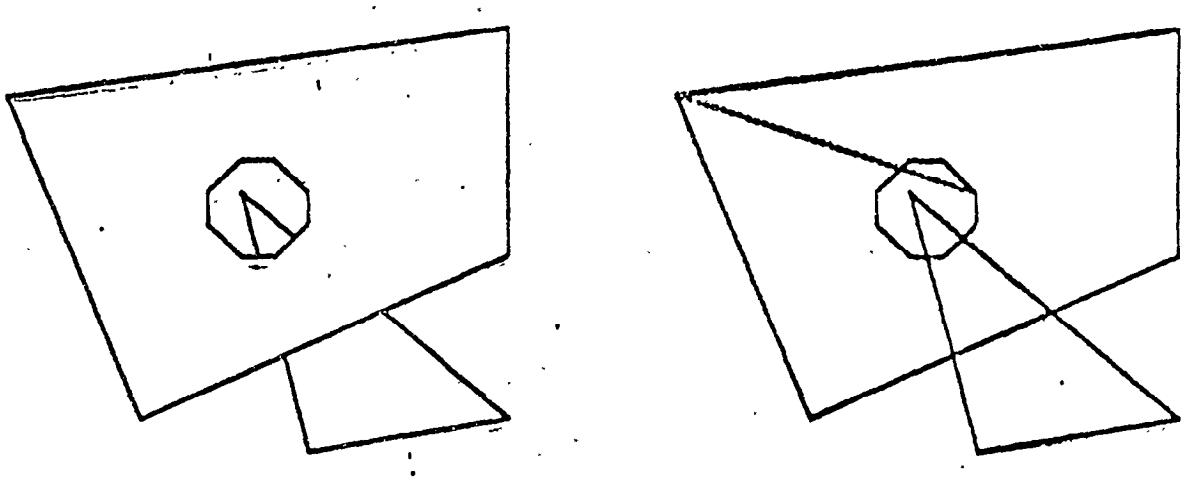


Exhibit 16

AUTODRAW

Automatic "dimensioning" of a tank top, obtained by ‘the user by pointing with the cursor on the desired locations.

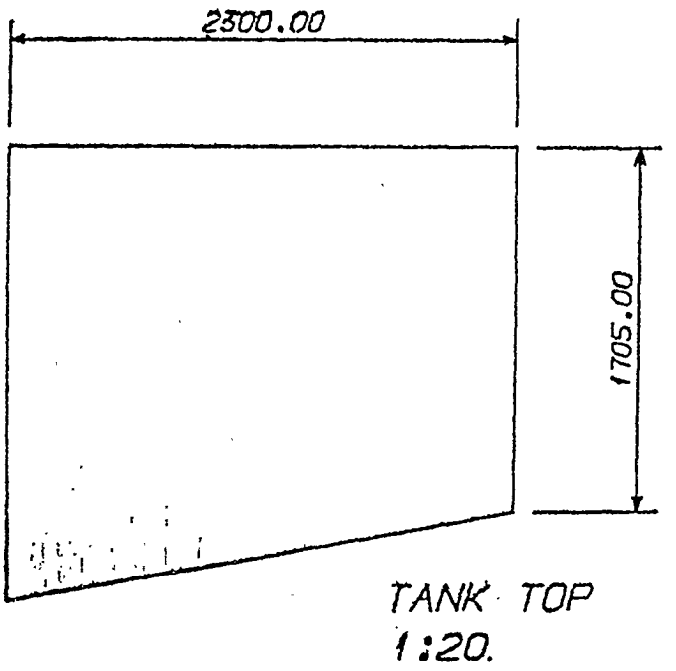
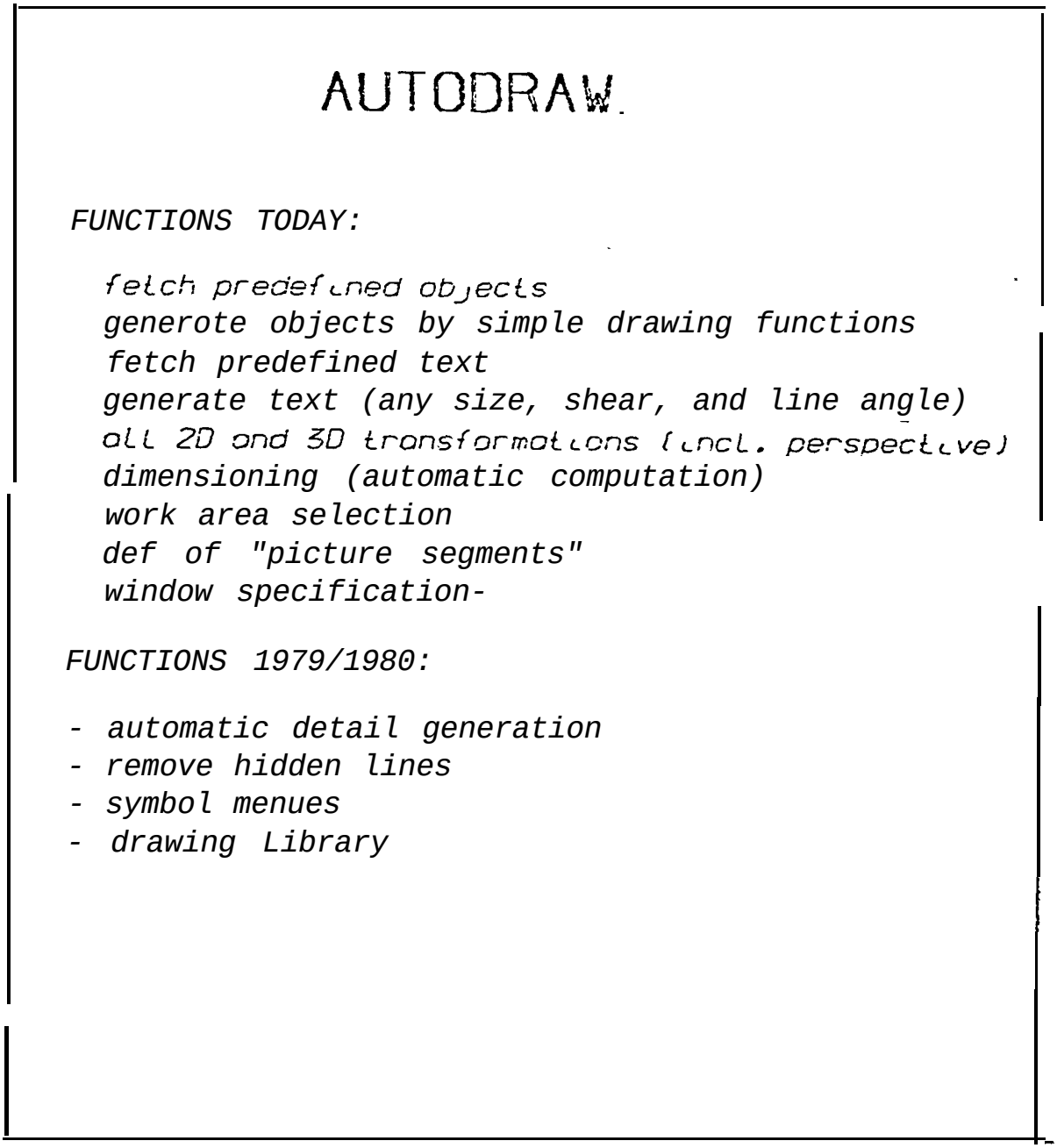


Exhibit 17

AUTODRAW

Hard copy with output from "texting" the facilities.



Exhibits 18 to 20 show an example using AUTODRAW in connection with an accommodation drawing. In this case the furniture have been defined by AUTOPART. Parts are not necessarily made of steel plates. By thinking in terms of "geometry" rather than in steel structure, it is obvious that imagination may make these modules usefull for many purposes.

AUTOPART and AUTODRAW are tightly connected. In fact, they may be regarded as a "tool kit" in which the user may easily switch from one tool to another. It means that any modification by AUTOPART will automatically update the drawing containing that part. It will also make a modification on the drawing that will lead to an update of the "product model". This link is under development.

In the overall AUTOKON context the practical implications of AUTODRAW are as follows:

Flexible work shop drawings

AUTOKON may be used to generate shop drawings which fit the principle "one job-one drawing". In other words, a hierarchy of shop drawings, that reflects the hierarchy of block, subassemblies, sub-sub assemblies, etc. down to parts. The "product model" contain the structure. The mentioned hierarchy of drawings is just another way of making work shop documentation than the tradional block drawing. In the latter all information are in one document.

Alternatively, assemblies may be shown in isometric or perspective views for clarification or as control drawings.

It is quite interesting to note that the above shop drawings are made from parts information, not as by tradition, the other way around.

Design drawings

Basically, design drawings may be regarded as high level "assembly" drawings, hence they may be generated as described above.

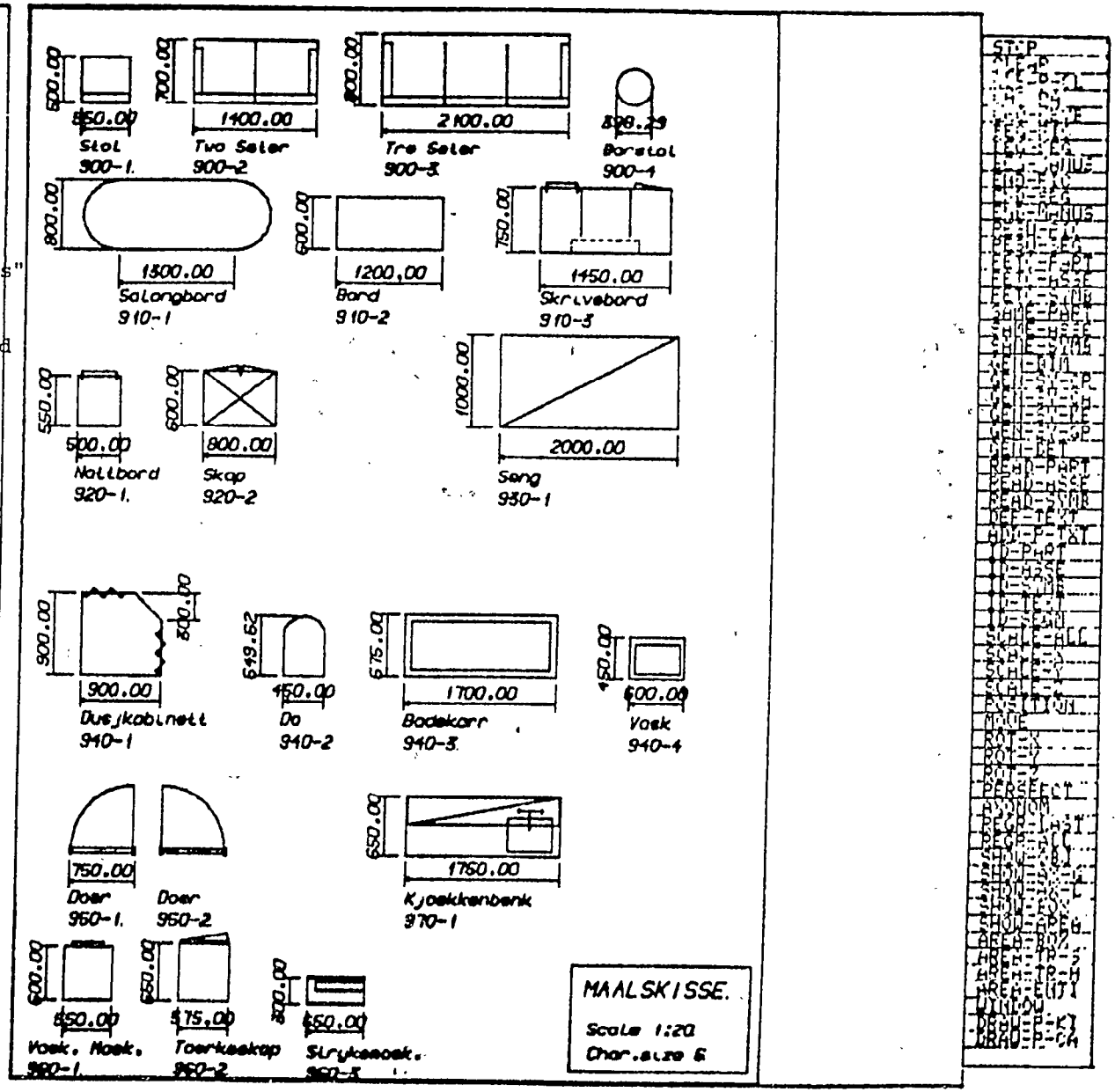
However, the whole idea of AUTOKON-79 is to generate various kind of design drawings at the earliest possible stage, where there are no parts. Therefore, we want to utilize the batch generated drawings from AUTOKON-79 as a departure point for further "treatment" by AUTODRAW.

SEND-PI PICTURE-1
[illegible] OPERATOR

Exhibit 18

AUTODRAW

Dealing with accommodation. The furniture are "parts" made by AUTOPART. This exhibit shows a catalogue produced by AUTODRAW.



Ehhibit 19

AUTODRAW

Accommodation plan produced by means of AUTODRAW based on the catalogue parts.
This cabin may be defined as a group of information that can be mirrored, rotated and moved as a whole.

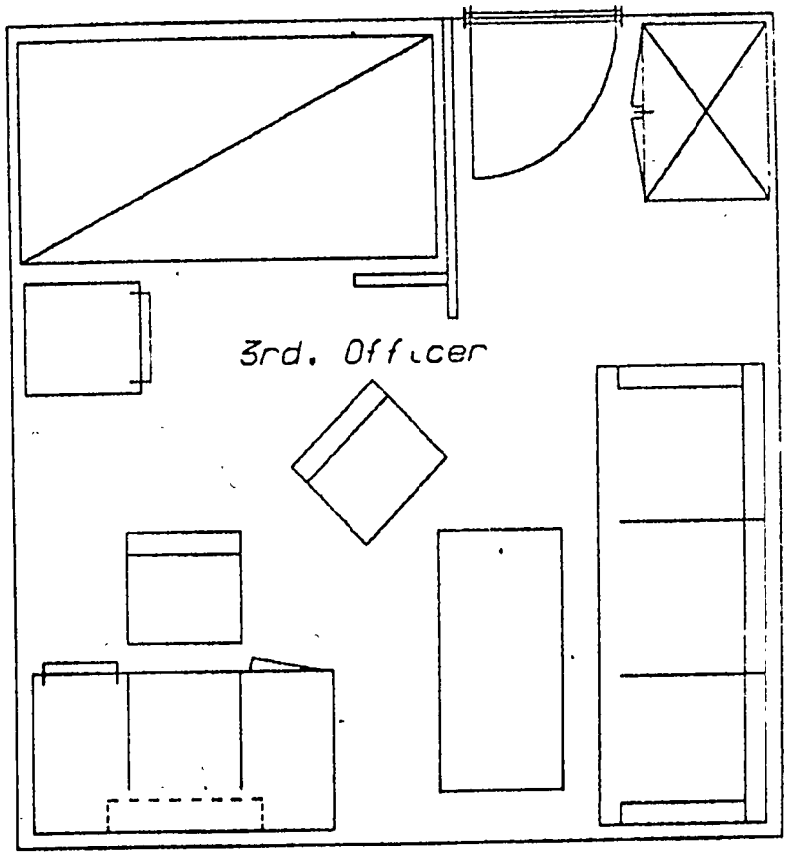
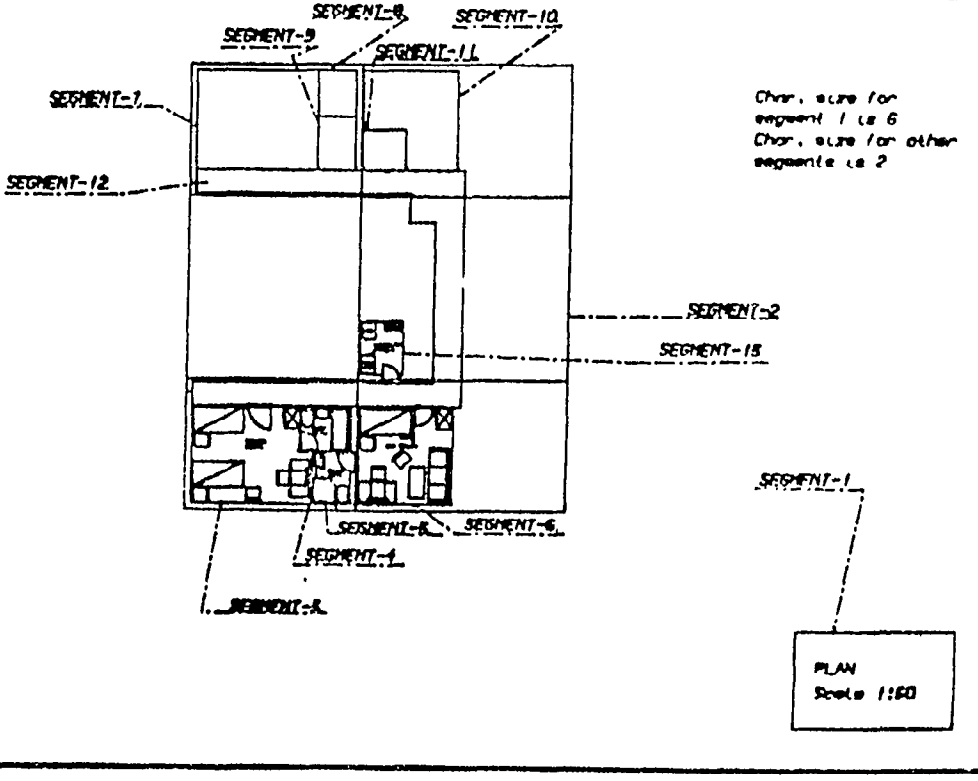


Exhibit 20

AUTODRAW

Building up an accommodation plan. It may either be a result of adding up a number of predefined "modules". Or the "steel bulkheads" defined first and the furniture arranged within the constraints.



We are simply using AUTODRAW as a pencil to complete the document. When making a plot of the completed drawing, the new "paper tape image will be the old one pluss the information we added by using AUTODRAW.

The observant reader will have noticed the difference from the way AUTOPART/AUTODRAW were used to generate drawings. In the first case we were communicating with the production oriented model, in the second with a document that originated from the design model of AUTOKON-79.

CONCLUDING REMARKS

AUTONEST is already a stable system proven in a actual production environment. AUTOPART is in its completion stage within the specifications, and will need some piloting before release. AUTODRAW has still some development ahead to complete the desired functions, which we believe will be satisfactorily covered. Our main concern is to search for better ways to implement AUTODRAW to improve efficiency and response time. The latter is quite crucial in order to have full user accept. We are quite confident we will find the remedies. It should be stressed once more, that even if AUTODRAW may be used for general drafting, its major objective is to manupulate predefined information. AUTOPART, AUTONEST and AUTODRAW will have its strength in their integration, first of all as an "auxilliary" and part of total AUTOKON. 'But also as a stand alone system for basically 2-D problems.